Factsheet 3

April 2007

Optimizing Ventilation System Performance

Agdex 720-3

EVALUATING LIVESTOCK HOUSING ENVIRONMENTS

A ventilation system provides the optimum indoor environment or indoor air quality (IAQ) for livestock. However, if there are flaws in the design of the ventilation system or the system was not installed properly, then the IAQ will be poor.

This situation will cause stress to the animals and operators as well as health problems. These problems may result in additional expenses and the loss of revenue to producers due to lower animal performance, the need for medication and increased mortalities.

Many barns are mechanically ventilated using exhaust fans to draw fresh outside air through the barn (i.e., under negative pressure) and exhausting barn air outside the building. This factsheet focuses primarily on negative air pressure mechanical ventilation systems. Essential components of these systems are as follows:

1. air inlet/distribution system
2. heating system
3. exhaust system
4. control system

Air Inlets and Distribution

Each type of animal housing requires a unique style of inlet. Poultry barns typically use a continuous baffle board on one or both sides of the barn. Swine housing requires smaller, modular, individual air inlets that are carefully located to direct air where it is needed while mechanically ventilated dairy barns use continuous baffle openings.

If the air supply into the barn is initially through the soffit and end gables and then the attic, a rise in barn air temperature of about 1.5 °C can be expected in summer because of solar effects. Any temperature rise above 1.5 °C will contribute to an excessively hot indoor environment. If this situation occurs, then steps must be taken to limit such increases in temperature. Such steps include the use of additional insulation under the barn roof or reflective radiant barrier ceramic paint.

Once inlets have been installed, regular adjustment and calibration are required, typically each spring and fall (**Figure 1**).

Figure 1. Calibration and adjustment of air inlets

Heating Systems

When cold weather arrives, so do the heating bills. Heat is required to allow the animals to thrive in an ideal environment. Without heat, feed costs will increase and animals will be susceptible to diseases.

Many types of heaters are available and the best type of heating system depends on the facility. Careful integration of the heating system with the overall ventilation system is essential. **Table 1** provides general recommendations for the most energy efficient systems of various facilities:

Forced air heaters: A fan circulates heated air from the heater through the barn. Since the air is hot, it tends to rise to the highest part of the barn, which can create a very warm ceiling and cold floor. This situation becomes more pronounced with ceilings over seven feet high. Recirculation systems can assist in minimizing this problem. Typically, this type of heating system is the least expensive (**Figure 2**).

Alberta

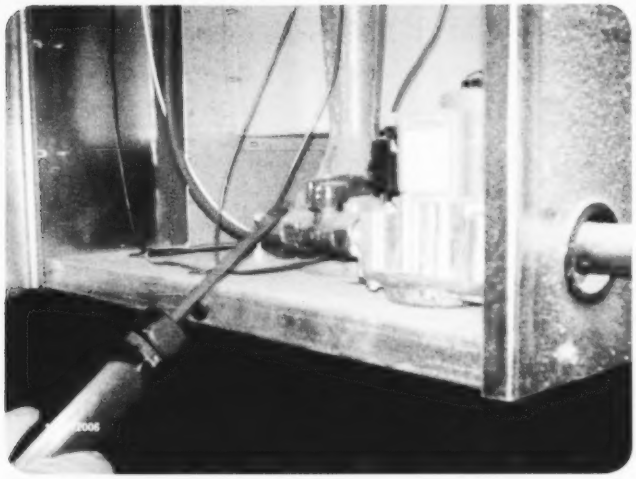


Figure 2. Adjusting the gas valve on some forced air heaters provides more efficient fuel use and helps maintain a steady barn temperature

Infrared heaters: The air is not heated, rather the objects below the heater are. This system keeps the heat down where the animals are and not up at the ceiling. Although this system is higher in initial cost than forced air heaters, the energy saved often pays for the higher capital investment in a few years.

Hot water in-floor radiant heaters: Hot water is pumped through pipes laid in concrete flooring. Although these systems should operate very efficiently, they quite often pose problems when the weather is erratic. Rapid increases in outside temperature leave the barn with a very warm floor and temperatures that are too warm (thermal lead) for the animals. On the other hand, rapid drops in temperature do not allow the heating system an opportunity to respond quickly enough because the hot water has to warm up the concrete floor first (thermal lag) before heat can be transmitted to the animals and room air.

Piped hot water heaters: Pipes are located close to the ceiling or along walls to distribute heat. Quite often, a series of thin metal sheets (fins) are attached perpendicular to the pipes to increase the transfer of heat from the pipes to the barn air.

Table 1. Recommended heat systems for livestock species

Species	Forced Air	Infrared	Fin Pipe	In-Floor Radiant	Comments
Dairy calves	✓	✓	✓	✓	
Dairy	✓	✓			Use infrared only for high ceilings
Swine farrow-piglets				✓	
Swine farrow-room	✓				
Swine breed/ gestation	✓	✓		✓	Use infrared with high ceiling only; use in-floor in combination with space heat
Swine nursery	✓	✓	✓	✓	Use in-floor in combination with space heat
Swine grow-finish	✓				Infrared with high ceiling only
Poultry brood	✓	✓	✓	✓	Recommended to use space heat with in-floor
Poultry grow	✓	✓	✓		
Poultry layer	✓		✓	✓	

2008-02612/

To make the most of the heating system, the following steps should be followed:

- Heaters come in different sizes, so ensure the heater is the proper size before purchasing it. This step is crucial because quite often, heaters are purchased that are grossly oversized. There seems to be a belief that an oversized heater is a guarantee there will always be sufficient heat in the barn.

  The problem with oversized heaters is that when the heater is turned on, it adds heat to the air far above the targeted temperature level. When this occurs, additional ventilation fans are turned on in the barn to cool it back down to the desired temperature. As cold outside air is drawn into the barn, the barn air cools rapidly below the targeted temperature level. The heater then turns on again to get the temperature back up to the desired level, repeating the heater and ventilation system on/off cycles.

  The frequent on/off cycling of the heater and fans wastes energy and introduces cold drafts into the barn. Typically in winter, the barn should only operate at minimum ventilation, and there should be no need for additional ventilation.

  A portable heater may be used to provide additional heat to the barn if necessary. This may occur in a situation where there are fewer animals than normal in the barn in a particular production cycle. Remember that the animals also contribute to the heat output of the barn. Although temporary periods of inadequate heat output in a barn are a concern, the negative effects are not as long-lasting as the negative effects of using an oversized heater.

- Many unvented gas heaters have a valve on them allowing the heater output to be reduced manually. In reality, heat output should be decreased for most of the year. With this approach, harmful by-products of combustion are kept at a minimum. It is only in severe cold weather or when preheating the barn that high heat output should be used. Other heating systems such as boilers and some infrared tube heaters vent their by-products of combustion outside the barn.

- Proper setting of the heating system controls is also critical. The right setting helps stabilize barn temperatures and ensures the operation of an energy-efficient heating system.

Exhaust Systems

Fan-based mechanically ventilated systems and naturally ventilated systems are the two most common types of livestock building ventilation systems. A third system would be a hybrid system. It combines and takes advantage of both the fan-based and naturally ventilated systems. In a hybrid system, fans are used to provide precise control and air distribution in winter. In warmer weather, the fans shut off and side walls open to allow air to flow naturally through the barn.

Regardless of what system is chosen, it is important to ensure that the following items are carefully considered:

- A good design is essential. The ventilation system design should include size, location, make and model of the fans. Note that some fans can only provide high volumes of air efficiently when there is little or no wind resistance. Other fans are more robust and can provide precise volumes of air against varying static pressures, which is important in cold weather.

- Staging when and how many fans turn on is important as well. A controller must be used to turn fans on and off in a given order to maintain the desired temperature. Note that oversized and undersized fans, or inadequate fans (poor selection), will lead to continued temperature fluctuations and health challenges (**Figure 3**).

- Independent assessment and calibration of the ventilation system are highly recommended after installation. Such an assessment will reveal any deficiencies such as barn leakage, under-performance of fans, and will guide the adjustment of the control system to optimize fan and heater operation.

Figure 3. Careful placement and sizing of fan stages is essential for proper ventilation systems performance

The control system is the brain of the entire ventilation system. Many different types of controllers are on the market; therefore, careful selection is required. You need to ensure the purchase of a controller that can best meet the requirements of the desired ventilation system. When selecting and using controllers, consideration should be given to the following:

- Ensure there are adequate control components on-board or available if required at a later date:

  . heat stage(s)
  . variable speed stage(s) control including feedback
  . multiple single speed stages
  . air inlet actuator control
  . cooling system control

. data logging, or at least high/low recall
. side wall panel and/or chimney control for natural ventilation

- Controller is located where it can be easily calibrated and verified.
- Commission the controller as soon as possible after stocking the barn.
- Check the sensor(s) calibration regularly, at least twice a year.
- Keep critical parts in stock in the event of breakdowns.
- Set the controller to get the best performance. Consider features such as automatic daily temperature changes to compensate for growing animals (**Figure 4**).

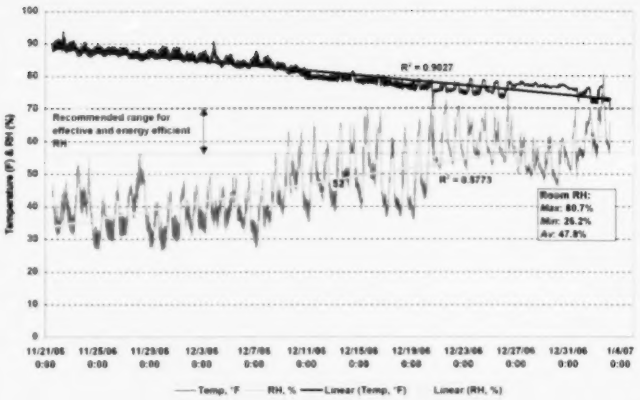


Figure 4. Controllers must be able to provide a consistent desired temperature throughout the growth cycle

Factsheets in this Series

Factsheet 1 **Principles of Measuring Indoor Air Quality**

Factsheet 2 **Instruments for Measuring Indoor Air Quality**

Factsheet 3 Optimizing Ventilation System Performance

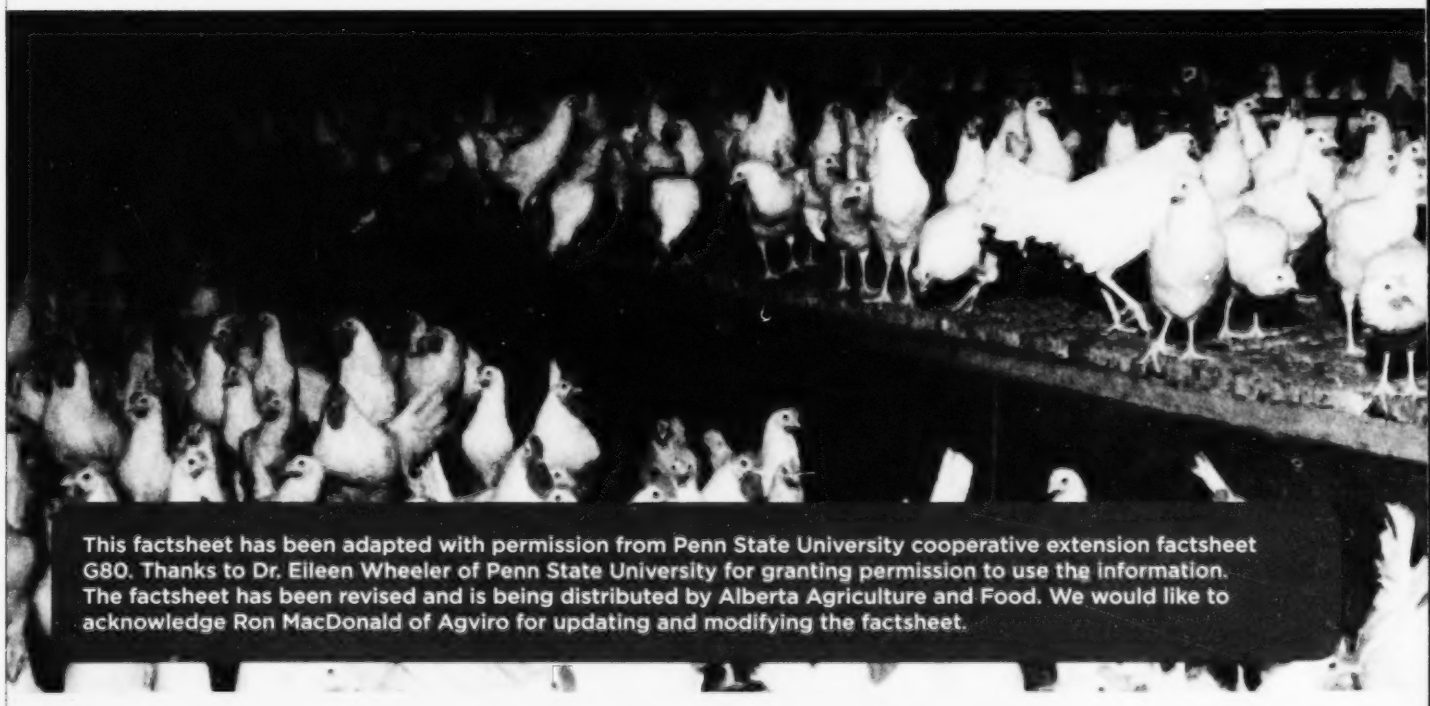
For additional copies in this series, contact Alberta Agriculture and Food's Publications Office: 1-800-292-5697

Summary

This factsheet provides guidance in optimizing ventilation system performance in livestock buildings. Efficient ventilation systems are necessary for optimum environmental conditions under which animals are housed.

For more information:

Alberta Agriculture and Food
#306, J.G. O'Donoghue Building
7000 – 113 Street
Edmonton, Alberta T6H 5T6
Phone: (780) 422-4844



This factsheet has been adapted with permission from Penn State University cooperative extension factsheet G80. Thanks to Dr. Eileen Wheeler of Penn State University for granting permission to use the information. The factsheet has been revised and is being distributed by Alberta Agriculture and Food. We would like to acknowledge Ron MacDonald of Agviro for updating and modifying the factsheet.